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Pine Valley Ridge Source—a Superior Selected Germplasm of Black Sagebrush

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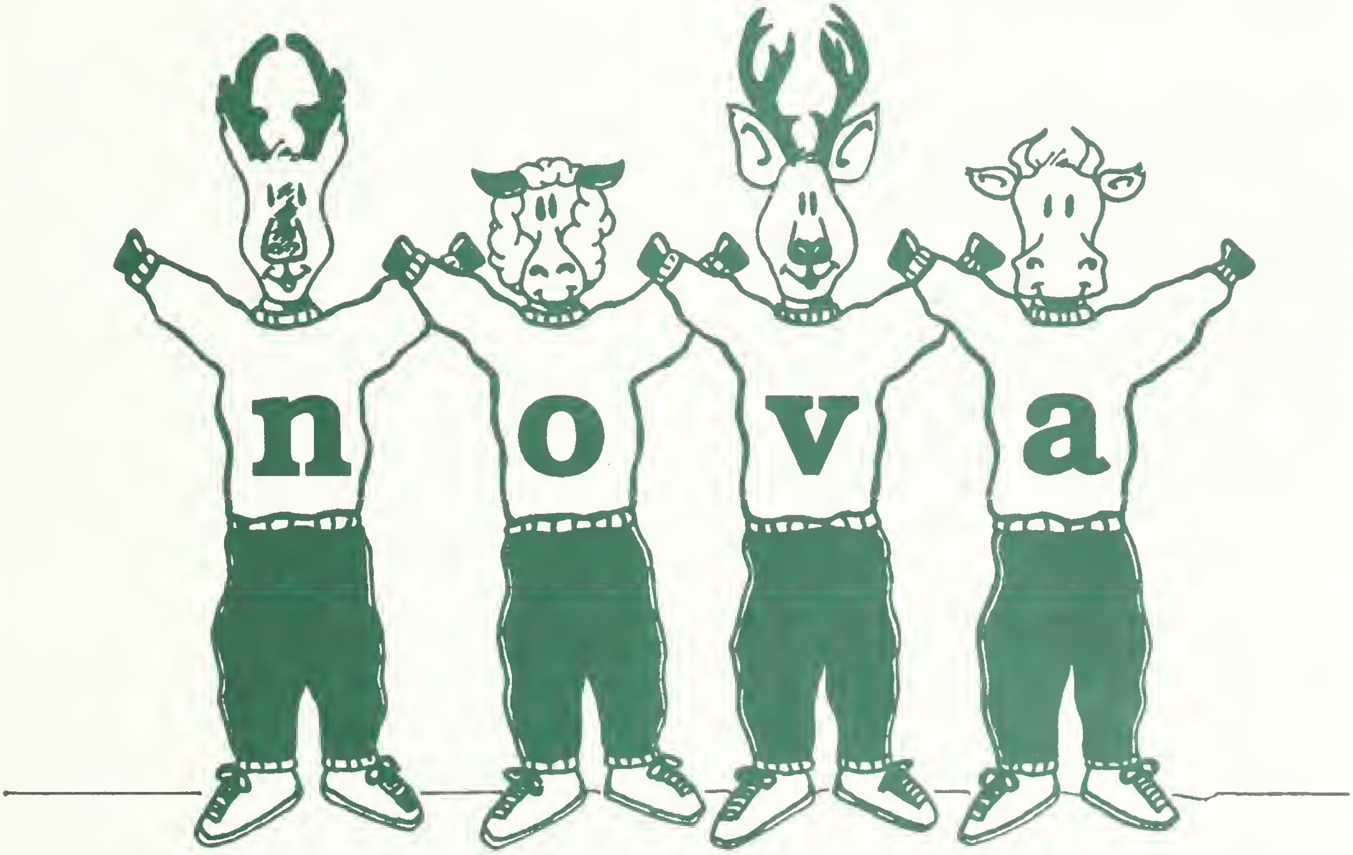

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Research Summary

This document establishes the basis for the release of Pine Valley Ridge source, a superior selected germplasm of black sagebrush (*Artemisia nova*). This ecotype of black sagebrush, a tetraploid ($2n = 36$), was collected near the northeast corner of the Intermountain Research Station's Desert Experimental Range, Millard County, UT. Its energy, crude protein, phosphorus, and carotene levels exceed those of most winter forages and will increase nutrients in the winter diets of pronghorn (*Antilocapra americana*), domestic sheep (*Ovis aries*), mule deer (*Odocoileus hemionus hemionus*), and cattle (*Bos bovine*). This black sagebrush is better adapted to drier sites than previously released germplasms: Gordon Creek (Wyoming big sagebrush, *A. tridentata* ssp. *wyomingensis*) and 'Hobble Creek' (mountain big sagebrush, *A. t.* ssp. *vaseyana*). Wintering mule deer preferred Pine Valley Ridge source over other black sagebrush germplasms tested. On its native site, Pine Valley Ridge is sought out by pronghorn year-round and by domestic sheep during winter. Cattle have been observed eating it during winter (Wagstaff 1994).

Pine Valley Ridge can be established and maintained over a wide geographic range on sites with the following characteristics: mean annual precipitation of 7 to 16 inches; deep to shallow, well-drained soils; soil clay content under 22 percent; soil pH from 6.6 to 8.8; and a frost-free period of at least 75 days.

Pine Valley Ridge can be established by direct seeding on properly prepared seedbeds, by transplanting bareroot or containerized stock, or by a technique termed "mother plant" in which shrubs transplanted on a 50- by 50-foot grid produce seeds to fill in the openings.

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The Need

Winter grasses, forbs, and deciduous shrubs are generally low in energy, protein, phosphorus, and carotene (Welch 1989, in press a,b). Most of the forages listed in table 1 provide less than the ungulate maintenance requirement for these nutrients (National Academy of Sciences 1975). The maintenance requirement is the level of a given nutrient needed to maintain body weight. For gestating females, the need is higher.

Only 7 of the 29 forages had in vitro digestibility of 50 percent, the maintenance requirement for energy (Ammann and others 1973). Two of the seven are evergreen shrubs: big sagebrush (*Artemisia tridentata*) and black sagebrush (*Artemisia nova*). Three shrubs, including black sagebrush, meet or exceed the maintenance requirement for phosphorus (0.18 to 0.28 percent of dry matter, National Academy of Sciences 1975). Five forages exceed the crude protein (7.0 to 8.9 percent of dry matter) and carotene (2.0 mg/kg of dry matter) maintenance requirements. These include one grass and four shrubs. Black sagebrush exceeds the maintenance requirements for energy, crude protein, and carotene and can provide the higher levels of these nutrients needed by gestating females. In short, black sagebrush can help raise the nutrient levels in winter diets.

Since 1986 two big sagebrush germplasms have been released for the commercial production of seeds and plants. 'Hobble Creek' (Welch and others 1986), a mountain big sagebrush (*A. tridentata* ssp. *vaseyana*), was the first to be released, followed by the Gordon Creek (Welch and others 1992) germplasm source of Wyoming big sagebrush (*A. t.* ssp. *wyomingensis*). 'Hobble Creek' was released for use on sites with at least 14 inches of annual precipitation. Gordon Creek was released for sites receiving from 10 to 14 inches of annual precipitation. Managers need a shrub that can raise the nutrient levels of winter diets on shrublands receiving less than 10 inches of annual precipitation. Black sagebrush meets this need. The evergreen nature of black sagebrush gives it a winter nutritional advantage over deciduous shrubs and herbaceous species.

Contradictory observations have been reported on the preference of wintering mule deer (*Odocoileus hemionus hemionus*) for black sagebrush. Blaisdell and Holmgren (1984) reported that black sagebrush was "highly palatable to (domestic) sheep, (pronghorn) antelope, and sage grouse." Clary (1986) reported similar observations for black sagebrush growing in the east-central area of the Great Basin. Nagy and Regelin (1977) reported that mule deer preferred black sagebrush over big sagebrush (*Artemisia tridentata*). However, Smith (1950), Sheehy and Winward (1981), and Personius and others (1987) reported that wintering mule deer preferred some sagebrush taxa over others, with black sagebrush the least preferred. Stevens and McArthur (1974) divided black sagebrush into two form classes, a and b. Class a tended to be more palatable and produced a bluer extract than class b. Water extracts of leaf material appear blue when exposed to long-wave ultraviolet light. Behan and Welch (1985) speculated that these differences may be due, in part, to genetic differences among the black sagebrush germplasms used in the various studies.

The Nutritive Profile

Behan and Welch (1985), studying the preferences of wintering mule deer for different germplasm selections of black sagebrush, reported that deer liked some selections better than others. Acquisition sites for germplasms used in their study are listed in table 2. All germplasms were established on a common garden at the Gordon Creek Wildlife Management Area near Helper, UT. The shrub garden is cooperatively maintained by the Utah Division of Wildlife Resources (Wildlife Restoration funds W-82-R, job 1) and the Intermountain Research Station. Preference was measured as the percentage of the length of the current year's vegetative growth that was eaten (table 3). Wintering mule deer preferred some germplasms of

Table 1—Winter nutritive value of selected range plants; data expressed as a percentage of dry matter (after Welch and others 1986). Scientific nomenclature follows Plummer and others (1977)

Plant name (common and scientific)	In vitro digestibility	Crude protein	Phosphorus
	Percent		
Grasses			
Bearded bluebunch wheatgrass			
Agropyron spicatum	45.5	3.2	0.05
Bluestem wheatgrass			
A. smithii	50.2	3.8	0.07
Bottlebrush squirreltail			
Sitanion hystrix	42.0	4.3	0.07
Crested wheatgrass			
A. desertorum	43.1	3.5	0.07
Crested wheatgrass, regrowth			
A. desertorum	50.6	15.0	0.39
Galleta			
Hilaria jamesii	48.2	4.6	0.08
Idaho fescue			
Festuca idahoensis	50.5	3.8	0.08
Indian ricegrass			
Oryzopsis hymenoides	50.5	3.1	0.06
Reed canarygrass			
Phalaris arundinacea	—	7.8	0.14
Needle-and-thread			
Stipa comata	46.6	3.7	0.07
Sandberg bluegrass			
Poa secunda	—	4.2	—
Sand dropseed			
Sporobolus cryptandrus	53.2	4.1	0.07
Smooth brome			
Bromus inermis	47.0	4.1	0.12
Shrubs			
Antelope bitterbrush			
Purshia tridentata	23.5	7.6	0.14
Big sagebrush			
Artemisia tridentata	57.8	11.7	0.22
Black sagebrush			
Artemisia nova	53.7	9.9	0.18
Cliffrose			
Cowania mexicana	37.6	8.6	—
Common winterfat			
Ceratoides lanata	43.5	10.0	0.11
Curlleaf mountain mahogany			
Cercocarpus ledifolius	49.1	10.0	—
Fourwing saltbush			
Atriplex canescens	38.3	8.9	—
Gambel oak			
Quercus gambelii	26.6	5.3	—
Low rabbitbrush			
Chrysothamnus viscidiflorus	36.0	5.9	0.15
Prostrate summer cypress			
Kochia prostrata	32.3	7.2	—
Rubber rabbitbrush			
Chrysothamnus nauseosus	44.4	7.8	0.14
True mountain mahogany			
Cercocarpus montanus	26.5	7.8	0.13
Utah juniper			
Juniperus osteosperma	44.1	6.6	0.18
Forbs			
Arrowleaf balsamroot			
Balsamorhiza sagittata	—	3.6	0.06
Oneflower helianthella			
Helianthella uniflora	—	2.8	0.17
Small burnet			
Sanguisorba minor	—	6.6	—

Table 2—Acquisition sites (locality by county and State) for germplasms of black sagebrush (*Artemisia nova*) (after Behan and Welch 1986)

Germplasm	County	State
Pine Valley Ridge	Millard	Utah (northeast of Desert Experimental Range)
Black Mountain	Sevier	Utah (near Salina)
Dove Creek	Dolores	Colorado (near Dove Creek)
Fremont Junction	Sevier	Utah (near Fremont Junction)
Manti	Sanpete	Utah (near Manti)
Spring Valley	White Pine	Nevada (junction of U.S. 93, 6, and 50)
Wingate Mesa	San Juan	Utah (near Fry Canyon)

Table 3—Preference of wintering mule deer (*Odocoileus hemionus hemionus*) for seven germplasms of black sagebrush (*Artemisia nova*) grown on a common garden. Data are expressed as the percentage of current year's annual growth that was eaten (after Behan and Welch 1985)

Germplasm	Mean percent eaten[1]
Pine Valley Ridge	82.7[a]
Spring Valley	59.7[b]
Wingate Mesa	40.6[c]
Fremont Junction	11.7[d]
Manti	7.1[d]
Dove Creek	3.4[d]
Black Mountain	0.0[d]

[1] Means sharing the same superscript are not significantly different at the 5 percent level.

black sagebrush over others with use varying from 0 to 82.7 percent of the current year's growth. Pine Valley Ridge germplasm, a tetraploid ($2n = 36$, McArthur and Sanderson 1994) was the most preferred. On its native site, domestic sheep, cattle, and pronghorn seek it out as a winter forage (Blaisdell and Holmgren 1984; Wagstaff 1994).

Behan and Welch (1986) studied the winter nutritive value of the seven germplasm selections of black sagebrush. Variables included productivity, crude protein, and in vitro digestibility.

Table 4 shows the mean productivity of the seven germplasms. Productivity was expressed as the length of the current year's vegetative growth. No significant differences were detected among the seven germplasms. Pine Valley Ridge's current year's growth rate was 4.5 centimeters.

Crude protein determinations (on a dry matter basis) are shown in table 5. Germplasms ranged from 5.8 to 7.3 percent crude protein. Although the differences were not significant, Pine Valley Ridge contained the highest percentage of crude protein. Except for fall regrowth of crested wheatgrass (*Agropyron desertorum*), Pine Valley Ridge's winter crude protein level exceeds grasses and forbs listed in table 1. As a shrub, however, its crude protein level is average.

Winter in vitro digestibilities of the seven black sagebrush germplasm selections are given in table 6. Although the differences were not significant, digestibility ranged from 51.9 to 57.2 percent of dry matter. The Manti germplasm was the most readily digested (57.2 percent). Pine Valley Ridge was 53.5 percent digested. The digestibility of Pine Valley Ridge ranked second to big sagebrush among the winter forages listed in table 1. Ammann and others (1973) estimated that dry-matter digestibility of 50 percent would provide sufficient energy for maintenance.

Behan and Welch (1986) did not include phosphorus as one of the nutrients in their study. Therefore, we conducted a study, as outlined by Behan and Welch (1986), to determine the winter phosphorus content of the seven black sagebrush germplasms. Germplasms ranged from 0.167 to 0.193 percent (table 7). No significant differences were detected among the germplasms. Pine Valley Ridge's winter phosphorus

Table 4—Mean productivity (length of leader growth) for seven germplasms of black sagebrush (*Artemisia nova*) grown on a common garden. No significant differences were detected among germplasms (after Behan and Welch 1986)

Germplasm	Leader growth
	cm
Fremont Junction	5.1
Dove Creek	4.6
Pine Valley Ridge	4.5
Manti	4.1
Wingate Mesa	3.9
Spring Valley	3.7
Black Mountain	3.7

Table 5—Mean winter crude protein (percent of dry matter) for seven germplasms of black sagebrush (*Artemisia nova*) grown in a common garden. Data are expressed as a percentage of dry matter. No significant differences were detected among germplasms (after Behan and Welch 1986)

Germplasm	Crude protein
	Percent
Pine Valley Ridge	7.3
Wingate Mesa	7.2
Dove Creek	7.1
Fremont Junction	6.9
Black Mountain	6.9
Manti	6.5
Spring Valley	5.8

Table 6—Mean winter in vitro digestibility (percent of dry matter digested) of seven germplasms of black sagebrush (*Artemisia nova*) grown on a common garden. No significant differences were detected among germplasms (after Behan and Welch 1986)

Germplasm	Digestibility
	Percent
Manti	57.2
Black Mountain	55.9
Fremont Junction	55.6
Dove Creek	55.6
Spring Valley	54.6
Pine Valley Ridge	53.5
Wingate Mesa	51.9

Table 7—Mean winter phosphorus content (percent of dry matter) of seven germplasms of black sagebrush (*Artemisia nova*) grown on a common garden. No significant differences were detected among germplasms

Germplasm	Phosphorus
	Percent
Dove Creek	0.193
Pine Valley Ridge	0.184
Manti	0.181
Spring Valley	0.181
Fremont Junction	0.177
Black Mountain	0.175
Wingate Mesa	0.167

level (0.184 percent) is exceeded by only two winter forages listed in table 1.

Behan and Welch (1985) studied the monoterpenoid content of the seven black sagebrush germplasms. Germplasms ranged from 0.63 to 1.33 percent monoterpenoids (table 8). Pine Valley Ridge germplasm contained the lowest amount of monoterpenoids. Differences among germplasms were not tested statistically.

In summary, the Pine Valley Ridge germplasm nutritive profile is: most preferred forage, 4.5 centimeter annual growth rate, 7.3 percent winter crude protein, 53.5 percent digestible winter dry matter, 0.184 percent winter phosphorus content, and 0.63 percent winter monoterpenoids.

Areas Where Pine Valley Ridge Can Be Grown

The native site of Pine Valley Ridge includes 80 acres about 1.25 miles northeast of the northeast corner of the Desert Experimental Range in Millard County, UT. The legal description is: the south half, of the southwest quarter of section 32, township 23 south, range 16 west, of the Salt Lake Meridian. Elevation is about 5,900 feet. The average annual precipitation is about 8 inches. The average frost-free period is from 100 to 150 days. The soils are of Amtoft and Lodar families. They are gravelly, sandy loam soils (Soil Conservation Service n.d.). Effective rooting depth is between 6 and 18 inches. Clay content is 22.2 percent (author's data on file). Soil reaction (pH) is 8.2. Permeability is moderate with an available water capacity of 1 to 3 inches (Blaisdell and Holmgren 1984; Utah State Engineer's Office 1931-1960).

Table 8—Mean monoterpenoid content (percent of dry matter) of seven germplasms of black sagebrush (*Artemisia nova*) grown on a common garden. Significant differences among germplasms were not tested (after Behan and Welch 1985)

Germplasm	Monoterpenoids
	Percent
Dove Creek	1.33
Fremont Junction	1.07
Spring Valley	1.07
Wingate Mesa	1.02
Black Mountain	0.75
Manti	0.70
Pine Valley Ridge	0.63

Pine Valley Ridge germplasm grows and reproduces on other sites. We have tested five, including: Springville, UT; Point of the Mountain (Bluffdale, UT), Gordon Creek Wildlife Management Area (Helper, UT), Round Valley (Challis, ID) and Spud Creek Alluvial (Clayton, ID).

Springville

Elevation is about 5,000 feet. Average annual precipitation is about 16 inches. The soil is a Pleasant Grove gravelly loam, a deep, well-drained soil derived from limestone, shale, and quartzite. Effective rooting depth is 5 feet or more. About 4 inches of available water is held by the soil to a depth of 5 feet. In summer, the soil can dry to depths of 7 to 20 inches for more than 60 consecutive days. Soil reaction (pH) ranges from 7.4 to 7.9. Clay content ranges from about 12 to 17 percent. The average frost-free period is about 160 days. Permeability ranges from 2.5 to 5.0 inches per hour (Swenson and others 1972).

Point of The Mountain

Elevation is about 4,500 feet. The average annual precipitation is about 12 inches. The soil is Bingham gravelly loam, a deep, well-drained soil derived from igneous and sedimentary rocks. About 4 inches of available water is held to a depth of 5 feet. Soil reaction (pH) ranges from 6.6 to 7.5. Most roots extend to a depth of less than 20 to 30 inches. The average frost-free period is about 160 days. Permeability ranges from 2.0 to 6.3 inches per hour (Utah State Engineer's Office 1931-1960; Woodward and others 1974).

Gordon Creek Wildlife Management Area

Elevation is about 6,900 feet. The average annual precipitation is about 12 inches. The soil is a Travessilla sandy loam. This is a shallow, well-drained soil derived predominantly from sandstone with 10 to 18 percent clay content. Effective rooting depth is between 7 and 20 inches. Soil reaction (pH) ranges from 7.4 to 8.8. Permeability is moderate with an available water capacity of 3 to 4 inches (Jensen and Borchert 1988; Utah State Engineer's Office 1931-1960).

Round Valley

Elevation is about 5,200 feet. The average annual precipitation is about 7 inches. The soil is a Snowslide very gravelly loam, a deep, well-drained soil. Effective rooting depth is 5 feet. About 5 inches of available water is held by the soil to a depth of 5 feet. Soil reaction (pH) ranges from 7.4 to 8.4. Clay content ranges from 5 to 18 percent. The average frost-free period is about 75 days. Permeability is moderate with an available water capacity of 5 to 6.5 inches (Lemhi Soil Conservation District 1993).

Spud Creek Alluvial

Elevation is about 5,700 feet. The average annual precipitation is about 9 inches. The soil is a Whiteknob gravelly loam. This is a deep, "somewhat excessively drained" soil of mixed geologic materials (Lemhi Soil Conservation District 1993). Clay content varies from 3 to 18 percent. Effective rooting depth is 5 feet or more, limited by discontinuity at 10 to 20 inches. Soil reaction (pH) ranges from 7.4 to 7.8. Permeability is moderate with an available water capacity of 1.5 to 3.5 inches (Lemhi Soil Conservation District 1993).

In Summary

Pine Valley Ridge germplasm appears to be widely adapted and can be grown on sites with the following physical characteristics: mean annual precipitation of 7 to 16 inches; deep to shallow, well-drained soils; clay content up to 22 percent; soil pH between 6.6 and 8.8; growing season of at least 75 days.

Establishment

Pine Valley Ridge can be established on suitable sites by direct seeding, by transplanting bareroot or containerized stock, or by a technique we term "mother plant." Descriptions of these techniques follow.

Direct Seeding Experiments

Because the annual precipitation of the native site and the Round Valley test site were below the 9-inch minimum recommended for artificial seeding (Blaisdell and Holmgren 1984; Plummer and others 1968) we experimented at the Desert Experimental Range to determine the feasibility of seeding this germplasm. Test plots were established at four sites. These sites were West Walt James (north half of the northwest quarter of section 22, township 25 south, range 18 west, Salt Lake Meridian); Warm Cove Pass (north half of the southwest quarter of section 25, township 25 south, range 18 west, Salt Lake Meridian); Old Highway (north half of the southeast quarter of section 25, township 24 south, range 18 west, Salt Lake Meridian); and Northeast Corner (south half of the southwest half of section 13, township 24 south, range 17 west, Salt Lake Meridian).

At each site four 10- by 10-foot plots were hand cleared of all vegetation. Two plots were used as controls. Control plots were established only for the first year. Two plots were seeded with Pine Valley

Ridge black sagebrush seed at a rate of one-eighth pound of pure live seed per acre (Welch and others 1986). Seeds were hand sown on the surface of the soil (Jacobson and Welch 1987). Plots were seeded in October 1987 for all but the West Walt James site. Two additional plots were seeded in October 1988 at all four sites. An additional two seeded plots were established in October 1989 at the West Walt James site. (No seeded or control plots were established at the West Walt James site in 1987.) Each site had two control plots and four seeded plots (two seeded plots were established during each of 2 years). Seedling counts were taken in the fall of 1993. To compare the success of artificial seeding versus natural seeding, the number of black sagebrush plants was noted in native plots 10 by 10 feet, just west of all seeded and control plots.

Plummer and others (1968) reported that if a site contained one desirable shrub plant per 100 square feet, the number of desirable shrubs could be increased without artificial seeding by reducing competition. If we accept this observation, then any plot with one seedling could be considered a success. As shown in table 9, only 2 of our 16 seeded plots contained just one seedling. The seeded plots had 143 4- to 6-year-old seedlings compared to 67 black sagebrush plants counted in the native plots. No black sagebrush seedlings were found in the control plots. Annual precipitation (estimated) for the three water years was: October 1987 to September 1989, 8.86 inches (111 percent of normal); October 1988 to September 1989, 7.07 inches (88 percent of normal); and October 1989 to September 1990, 6.89 inches (86 percent of normal) (NOAA 1988, 1989, 1990; Utah State Engineer's Office 1931-1960). Even in the very driest year (October 1989 to September 1990), the West Walt James plots seeded in October 1989 produced nine seedlings that survived 4 years. We concluded from this experiment that Pine Valley Ridge black sagebrush can be established by direct seeding on sites having less than 9 inches of annual precipitation.

Direct Seeding

Direct seeding is the most practical method for establishing Pine Valley Ridge. A successful

Table 9—Number of 4-to-6-year-old Pine Valley Ridge plants produced on seeded plots (10 by 10 feet) at four different sites on the Desert Experimental Range. The number of native black sagebrush plants on plots of the same size adjacent to the seeded and control plots are given. Data were collected during the fall of 1993

Site	Plot	Date seeded	Number of seeded plants	Number of native plants
Northeast	Seeded 1 South	10/87	7	0
	Seeded 2 South	10/88	3	2
	Control South	—	0	0
	Seeded 1 North	10/87	3	0
	Seeded 2 North	10/88	2	0
	Control North	—	0	0
Old Highway	Seeded 1 South	10/87	37	0
	Seeded 2 South	10/88	45	23
	Control South	—	0	4
	Seeded 1 North	10/87	4	0
	Seeded 2 North	10/88	1	2
	Control North	—	0	0
Warm Cove Pass	Seeded 1 South	10/87	12	9
	Seeded 2 South	10/88	8	7
	Control South	—	0	3
	Seeded 1 North	10/87	1	0
	Seeded 2 North	10/88	3	0
	Control North	—	0	0
West Walt James	Seeded 1 West	10/88	4	7
	Seeded 2 West	10/89	5	0
	Control West	—	0	2
	Seeded 1 East	10/88	4	4
	Seeded 2 East	10/89	4	2
	Control East	—	0	2

direct-seeding program starts with high-quality, certified seed (green tag, Selected Class). Commercial sources of certified Pine Valley Ridge germplasm seed will be available by May 1994. Techniques have been developed to economically clean the seed to a pure live seed content of 40 to 50 percent (Shaw and Monsen 1990; Welch, in preparation; Welch and others 1986). Storage life of black sagebrush seed in an open, unheated, uncooled warehouse is about 3 years (Shaw and Monsen 1990; Stevens and others 1981). If the seed analysis is older than 1 year, seedlots should be tested for germination before being used in a direct seeding program.

After a suitable site has been chosen, the site should be prepared by reducing competition. Vegetation can be cleared by fire, herbicides, or machinery. The amount of vegetation removed will depend on the amount and kinds of other forage species seeded with Pine Valley Ridge. We recommend planting Pine Valley Ridge with other forage species because mixtures are more productive than monocultures. Mixtures extend the season of use and are more resistant to diseases and insects (Plummer and others 1968). Pine Valley Ridge should be sown at the rate of one-eighth to one-fourth pound of pure live seed per acre (Plummer and others 1968; Richardson and others 1986; Shaw and Monsen 1990; Welch and others 1986). The timing and depth of seeding are critical. On the native site, Pine Valley Ridge disperses its seed in November. Therefore, we believe the best time to sow the seed is just before snow accumulation (Young and Evans 1986). For a mixture, the optimum planting depth will depend on the different species included. Pine Valley Ridge seed should be sown on a firm seedbed at or near the surface. Big sagebrush seeds are about the same size as black sagebrush seeds. In greenhouse studies, almost no seedlings emerged when big sagebrush seeds were planted deeper than three-sixteenths of an inch (Jacobson and Welch 1987). Frost heaving and the expansion and contraction of the soil surface by wetting and drying will cover the sagebrush seeds sufficiently to allow them to germinate and become established. Pine Valley Ridge seed can be sown by aerial seeders, cyclone seeders, dribblers, or drills that have been adjusted to leave the seeds on the surface. When using a drill, Richardson and others (1986) recommended that sagebrush and other shrubs be planted in different rows than grasses and forbs. Because grasses and forbs develop more quickly, they may keep shrubs from becoming established. This planting technique also requires less shrub seed. Competition within the seed mixture is reduced when seed is sown aerially or broadcast on a prepared, firm seedbed. Competition can be reduced by increasing microhabitat diversity through roughening the soil surface, for instance, by disking or harrowing (Young and Evans 1986).

Transplanting Bareroot and Containerized Stock

Expense limits the usefulness of transplanting bareroot or containerized stock to small critical areas, seed increase gardens, or demonstration plots. Planting stock should be at least 5 to 8 inches tall and overwintered in an unheated nursery bed or lathhouse. We recommend transplanting stock in early spring. However, containerized stock can be successfully transplanted in the summer if the transplants receive adequate irrigation during the first growing season.

A 0.5- to 1-square-foot area must be cleared of all competing plants for each transplant. A shovel can be used to mix the soil and kill the tops, roots, stolons, and rhizomes of competing species. Soil must be packed firmly around the transplant's entire root system. To enhance survival and growth, a basin 1 to 3 inches deep could be constructed around the stem to catch water. In extremely dry areas or during dry periods, the basin can be filled with water. For containerized stock, the growing medium should be covered with 0.5 inch of soil. This prevents the growing medium from acting as a wick and drying out the transplant. First-year survival rates should be 80 percent or higher.

"Mother Plant"

This technique combines transplanting and natural seed dispersal. Shrubs established by transplanting can serve as mother plants to produce seeds for dispersal. This technique can be used after a disturbance has destroyed a native stand of black sagebrush. The mother plants are planted on a 50- by 50-foot grid throughout the site. The plants may have to be individually fertilized, irrigated, fenced, or otherwise cared for if they are to be come established and grow.

After 3 to 5 years, the mother plants should produce seed. Competing vegetation can be cleared in strips or in spots around the mother plants using machinery or herbicides. This technique can help maintain black sagebrush stands that receive heavy use year after year (Wagstaff and Welch 1990). Heavy grazing may reduce seed stalk (and hence seed) production to one-thirtieth or one-fiftieth of normal (Wagstaff 1994; Wagstaff and Welch 1991).

Conclusions

Pine Valley Ridge source is a superior selected germplasm of black sagebrush for revegetating a variety of dry habitats. It was preferred by wintering deer; a number of other domestic and wild animals eat it as well. It can raise the level of energy, crude protein, phosphorus, and carotene in the diet of a number of wintering animals. Pine Valley Ridge black sagebrush germplasm can be established by direct seeding, transplanting, and the use of the "mother plant" technique. It appears to be widely adapted and can grow on sites with the following physical characteristics:

- Mean annual precipitation of at least 7 inches.
- Deep to shallow, well-drained soils.
- Clay content up to 22 percent.
- Soil pH between 6.6 and 8.8.
- Growing season of at least 75 days.

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A superior germplasm of black sagebrush (*Artemisia nova*) has been evaluated for revegetating arid rangeland with annual precipitation of 7 to 16 inches. This germplasm, Pine Valley Ridge, can increase the level of energy, protein, phosphorus, and carotene in the diet of wintering pronghorn, domestic sheep, cattle, and mule deer. Pine Valley Ridge is better adapted to drier sites than two previously released germplasms of big sagebrush, 'Hobble Creek' and Gordon Creek. The need for the germplasm, its nutrient content, characteristics of areas where it can be grown, and procedures for establishing it are described.

Keywords: forage preference tests, winter range, nutritive value, establishment, revegetation, *Artemisia nova*, pronghorn, sage grouse, cattle, domestic sheep, browse plants, rehabilitation

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